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NEWLY DISCOVERED LEAFHOPPER VECTORS OF CALIFORNIA ASTER-YELLOWS VIRUS[1]

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INTRODUCTION

SOME YEARS AGO three species of leafhoppers and a biological race of one of them were reported to transmit the California aster-yellows virus (Severin, 1929, 1934, 1940).[3] Recently eight additional leafhopper species were added to the list of vectors of this virus (Severin, 1945, 1946, 1947).

The present paper deals with five newly discovered leafhopper vectors of this virus. In a companion paper DeLong and Severin (1947) discuss the characters, distribution, and food plants of these species.

An investigation was undertaken on the efficiency of the vectors in transmitting the virus by single males and females to healthy celery and asters. Multiple-lot tests were performed with several species. With three species, studies were made of the retention of the virus in single adults. Natural infectivity tests were made with two species. With some species, attempts were made to transmit the viruses of curly top to sugar beets and Pierce's disease of grapevines to grapevine cuttings or seedlings and the identical virus from alfalfa dwarf to healthy alfalfa.

The technique and equipment have been described in previous papers (Severin, 1930, 1931, 1945, 1946, 1947).

CLOANTHANUS IRRORATUS (VAN DUZEE)

(Plate 1, *A*, *B*)

Transmission of Virus to Celery and Asters. Fifty recently molted males and 50 females of *Cloanthanus irroratus* (Van Duzee), which had completed the nymphal stage on diseased celery, were kept singly on 100 celery plants until symptoms of the disease developed or during adult life if no symptoms ap-

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[3] See "Literature Cited" for citations, referred to in the text by author and date.

peared. Table 1 shows that only 1 of 50 males caused an infection, and none of the 50 females.

Lots of 5, 10, 20, and 40 adults were transferred from infected to healthy celery plants and when symptoms of the disease developed, each lot was changed to a healthy aster. If no symptoms appeared on celery at the end of approximately 2 months, then the surviving adults in each lot were transferred and kept on a healthy aster until the last leafhopper died. There was a progressive increase in the percentages of infections of celery with lots of 5, 10, 20,

TABLE 1

TRANSMISSION OF VIRUS TO CELERY AND ASTERS, BY VARYING NUMBERS OF ADULT *Cloanthanus irroratus*

Number of lots	Number and sex of adults in each lot	Celery (first set of plants)			Asters (second set of plants)		
		Plants inoculated	Plants infected	Per cent infected	Plants inoculated	Plants infected	Per cent infected
50	1 male	50	1	2	..	..	..
50	1 female	50	0	0	..	..	..
60	5 males	60	6	10	60	1	2
63	10 males	63	8	13	63	0	0
53	20 males	53	14	26	53	0	0
77	40 males	77	41	53	77	8	10

TABLE 2

TRANSMISSION OF VIRUS TO ASTERS BY VARYING NUMBERS OF ADULT *Cloanthanus irroratus*

Number of lots	Number and sex of adults in each lot	Asters inoculated	Asters infected	Per cent infected
50	1 male	50	1	2
50	1 female	50	0	0
10	20 males	10	0	0
43	40 males	43	8	19

and 40 leafhoppers, as shown in table 1, indicating that the number of leafhoppers plays an important role in the transmission of the virus. There was, however, no progressive increase in the percentages of infection of asters.

Since a mortality of the leafhoppers occurred on healthy celery in the previous experiment, another test was made with lots of varying numbers of males or females transferred from diseased celery to healthy asters. Table 2 shows that only 1 aster was infected by 50 males and 50 females tested singly on asters. Lots of 20 males caused no infections. Lots of 40 males infected 19 per cent of the asters as compared with 10 per cent in the previous experiment (table 1).

Retention of Virus by Single Adults. The retention of the virus was determined with the only leafhopper—a male—that produced an infection of celery in the single-insect tests (table 1). The first celery plant showed symp-

toms at the end of 19 days. The leafhopper was then transferred daily to successive healthy celery plants during adult life; it transmitted the virus to another celery plant 15 days after the first infection. The incubation period of the disease of the first infection cannot be included in the retention of the virus, since the leafhopper had an opportunity to acquire additional virus after the first celery plant became infected. The longevity of the male was 76 days.

Attempts to Transmit Viruses of Curly Top and Pierce's Disease of Grapevine. Seventeen lots of 20 male *Cloanthanus irroratus*, after feeding on curly-top beets from 1 to 2 weeks, failed to transmit the virus to 17 healthy beets. Fifteen lots of 40 noninfective *C. irroratus* failed to transmit the virus of Pierce's disease of grapevines to healthy grape seedlings and to plants of California Common or Chilean alfalfa, *Medicago sativa;* or from alfalfa dwarf to healthy grape and alfalfa plants.

CLOANTHANUS DUBIUS (VAN DUZEE)

(Plate 1, *C, D*)

Transmission of Virus to Celery. The efficiency of *Cloanthanus dubius* (Van Duzee) in transmitting the virus was determined with 50 males and 50 females, each kept singly on a healthy celery plant. If symptoms of the disease developed, each surviving leafhopper was used in determining the retention of the virus, and if no symptoms appeared, the adults were kept on each healthy celery plant during adult life. Eleven males and 2 females, or 13 per cent, caused infections.

Tests were made on the transmission of the virus by lots of 20 and 40 males, each transferred weekly to 6 successive healthy celery plants, and by lots of the same number of males transferred at intervals of 2 weeks. As table 3 shows, the total percentage of infection in weekly inoculations was 23 both for lots of 20 and for lots of 40 adults, as compared with 27 and 47 per cent with lots of 20 and 40 males at 2-week intervals.

TABLE 3

TRANSMISSION OF VIRUS TO SUCCESSIVE CELERY PLANTS BY VARYING NUMBERS OF MALE *Cloanthanus dubius*

Period of inoculations and number of adults in each lot	Plants infected in each set*						Total		
	First set	Second set	Third set	Fourth set	Fifth set	Sixth set	Plants inoculated	Plants infected	Per cent infected
Weekly inoculations:									
20	1	1	1	2	2	0	30	7	23
40	1	1	1	1	1	2	30	7	23
Inoculations every 2 weeks:									
20	1	3	2	0	0	1	30	8	27
40	4	4	4	1	1	0	30	14	47

* Five plants inoculated in each set.

Attempts to Transmit Virus to Asters. Fifty males and 50 females, each kept singly on healthy asters, failed to cause infections. The males lived from 1 to 12 days, an average of 3.3 days, and the females from 1 to 7 days, an average of 2.4 days, on healthy asters.

One lot of 40 males was caged on a healthy aster and after 2 weeks the surviving adults, 7 in number, were transferred to a second aster, but no infection occurred.

Retention of Virus by Single Adults. The retention of the virus was ascertained with adults previously used in determining the efficiency of the vector in transmitting virus by single insects. After the first infection the leafhoppers were transferred daily to successive healthy celery plants during adult life.

TABLE 4

RETENTION OF VIRUS BY SINGLE ADULTS OF *Cloanthanus dubius* WITH CELERY AS THE HOST PLANT

Insect no. and sex	Days on first plant before symptoms developed	Plants inoculated after initial infection	Plants infected after initial infection	Per cent infected after initial infection	Days after initial infection on which successive infections occurred	Longevity of adults, days
No. 1, male	36	28	4	14	17, 22, 27, 28	64
No. 2, male	22	55	3	5	23, 24, 29	77
No. 3, male	28	135	2	2	1, 2	163
No. 4, male	46	5	1	20	2	51

Table 4 shows that the virus was retained from 1 to 29 days. As with *Cloanthanus irroratus*, the incubation period of the disease of the initial infection is not included in the retention of the virus.

Attempt to Transmit Curly-Top Virus. Extensive tests were made to determine whether this species of leafhopper was a vector of the curly-top virus. All attempts to transmit the curly-top virus to healthy sugar-beet seedlings were negative.

EUSCELIS MACULIPENIS DeLONG AND DAVIDSON

(Plate 1, *E*, *F*)

Transmission of Virus to Celery. The efficiency of *Euscelis maculipenis* DeLong and Davidson in transmitting the virus was determined with recently molted males and females, reared during the nymphal stages on diseased celery, and then each adult was transferred singly to a healthy celery or aster plant. Single males and females infected 78 and 76 per cent of the celery plants, respectively, but none of the 100 asters inoculated, as shown in table 5.

When symptoms developed on celery, some of the insects were transferred singly to a second celery plant. These leafhoppers had an opportunity to acquire the virus again from the first infected celery. Eighteen of 21 males

infected 18 of 21 plants, or 86 per cent. Seventeen females each infected a celery plant, but when transferred singly to healthy asters failed to infect any.

The longevity of the males on healthy asters ranged from 1 to 35 days, with an average of 3 days; females 1 to 24 days, with an average of 3 days.

TABLE 5

TRANSMISSION OF VIRUS BY THREE VECTORS TESTED SINGLY TO TWO HOST PLANTS

Vector	Tests on celery			Tests on aster		
	Plants inoculated	Plants infected	Per cent infected	Plants inoculated	Plants infected	Per cent infected
Euscelis maculipenis:						
Males	50	39	78.0	50	0	0
Females	50	38	76.0	50	0	0
Short-winged aster leafhopper, *Macrosteles divisus:*						
Males	0	..	....	125	82	66
Females	100	69	69.0	25	22	88
Long-winged aster leafhopper, *Macrosteles divisus:*						
Males	0	..	....	125	80	64
Females	100	9	9.0	25	13	52

TABLE 6

RETENTION OF VIRUS WITH SINGLE ADULT *Euscelis maculipenis* WITH CELERY AS THE HOST PLANT

Sex and number of vector	Days on first plant before symptoms developed	Plants inoculated after first infection	Plants infected after first infection	Per cent infected after first infection	Retention of virus, days	Longevity of adults, days
Males:						
No. 1	17	60	19	32	59	77
No. 2	41	50	11	22	50	91
No. 3	42	50	6	12	50	92
No. 4	36	32	11	34	31	68
No. 5	35	30	8	27	29	65
No. 6	31	29	8	28	29	60
No. 7	51	30	8	27	20	81
No. 8	14	14	10	71	13	28
No. 9	17	98	5	5	5	115
No. 10	17	108	3	3	5	125
No. 11	15	2	2	100	2	17
No. 12	36	5	1	20	4	41
Females:						
No. 1	24	4	2	50	13	28
No. 2	19	10	6	60	9	29
No. 3	65	8	5	63	7	73
No. 4	45	10	6	60	7	55
No. 5	65	8	5	63	7	73
No. 6	21	7	3	43	7	28
No. 7	32	7	1	14	7	39
No. 8	24	7	2	29	5	31
No. 9	15	5	2	40	5	20
No. 10	35	4	1	25	4	39
No. 11	47	4	2	50	3	51
No. 12	61	3	0	0	0	64

Retention of Virus by Single Adults. The retention of the virus was determined with single males and females that had transmitted the virus in tests of vector efficiency. Each insect was provided with a healthy celery plant daily during adult life. The results appear in table 6. As this table shows, the males retained the virus from 2 to 59 days, and the females from 3 to 13 days. The period before symptoms developed on the first celery plant is not included in virus retention, since the adult was able to recover the virus again. One male produced only 1 infection.

Natural Infectivity. Plantain, or ribgrass, *Plantago major*, growing in an alfalfa field near Milpitas and along roadsides, was found commonly infected with aster yellows. Nymphs and adults were often collected in this alfalfa field in the spring, but during the autumn the adults were rarely taken. Two adults captured in this alfalfa field on August 23, 1945, did not transmit the virus to celery.

Sweepings were made on common dandelion, *Taraxacum vulgare*, growing in South San Francisco, on August 20, 1945, and 3 nymphs and 30 adults were taken in half an hour. Some of the dandelion plants were infected with aster yellows, but the virus was not transmitted to celery.

Attempts to Transmit Viruses of Curly Top and Pierce's Disease of Grapevines. Ten lots of 5 adults, after feeding on curly-top beets for a period of 4 days, failed to transmit the virus to 10 healthy sugar-beet seedlings. The longevity of the adults ranged from 18 to 69 days.

No success was achieved in attempts to transmit the virus of Pierce's disease of grapevines from diseased vines to healthy wild-grape seedlings or from alfalfa plants infected with dwarf to healthy grape seedlings with this leafhopper.

MACROSTELES DIVISUS (UHLER)

Further Tests of Efficiency of Virus Transmission. In working with a large number of newly discovered leafhopper vectors of the California aster-yellows virus, it soon became evident that the ability to transmit the virus varied with different species. For the purpose of comparison, efficiency tests were conducted with the short-winged and long-winged aster leafhoppers, *Macrosteles divisus* (Uhler), which are known to be efficient vectors of the virus. The long-winged aster leafhopper is a biological race (Severin, 1940).

Short-winged and long-winged aster leafhoppers were reared on asters and on celery infected with the virus. High populations of infective short-winged aster leafhoppers were reared on diseased celery and low numbers of noninfective adults on healthy celery. Low populations of infective long-winged adults were obtained on diseased celery, but the nymphs died after the first molt on healthy celery.

Transmission of Virus to Celery and Asters. The efficiency of both vectors in transmitting the virus was determined with single leafhoppers. Twenty-five to 125 males and females that had completed the nymphal stages on diseased

celery or asters were kept singly on healthy celery or asters until symptoms developed, or during adult life if no symptoms appeared. The results obtained are given in table 5.

As shown in table 5, short-winged aster leafhoppers tested singly infected 69 per cent of the celery plants, and 66 to 88 per cent of the asters, or an average of 69 per cent. Long-winged aster leafhoppers infected 9 per cent of the celery and 52 to 64 per cent of the asters, or an average of 62 per cent.

The longevities of 4 long-winged males which caused infections were 1, 10, 31, and 42 days, or an average of 26 days, and of 5 females 4, 6, 22, 28, and 42 days, or an average of 20 days. The longevity of 46 males which failed to cause infection ranged from 1 to 40 days, with an average of 6 days, and of 45 females from 2 to 38 days, with an average of 14 days.

Natural Infectivity. A comparison was also made of the natural infectivity of short-winged aster leafhoppers with *Euscelis maculipenis* collected on the same dates in the same habitats. Fifteen short-winged aster leafhoppers captured in an alfalfa field near Milpitas transmitted the virus to asters, but *E. maculipenis* failed to transmit it to celery. Eleven short-winged aster leafhoppers taken on common dandelion growing in South San Francisco transmitted the virus to asters, but 3 nymphs and 30 adults of *E. maculipenis* failed to infect celery.

FIEBERIELLA FLORII (STÅL)

(Plate 1, *G*, *H*)

Adult *Fieberiella florii* (Stål) collected in the field were kept on infected celery for 10 days or longer to complete the latent period of the virus in the insect. Fifty males and 50 females tested singly on healthy celery plants during adult life, transmitted the virus to 9 plants, or 18 per cent, and 11 plants, or 22 per cent, respectively. Eighteen lots of 5 adults produced 8 infections, or 44 per cent.

CHLOROTETTIX SIMILIS DeLONG

(Plate 1, *I*)

Chlorotettix similis DeLong has not been reared on any food plants up to the present time. This is further discussed in a companion paper (DeLong and Severin, 1947).

Adults collected in the field were kept on infected celery plants for 10 days or longer. Eight leafhoppers were then transferred singly and kept on healthy celery plants during adult life. The rest of the leafhoppers were transferred in multiple lots to successive healthy celery plants. One of the 8 adults in single-insect tests infected 1 plant. One lot of 3 adults transmitted the virus to 1 of 2 plants. One lot of 30 adults produced 1 infection and 13 surviving adults caused another infection. Lots of 16 and 20 adults failed to transmit the virus to 5 celery plants. Of the total of 17 plants inoculated, 4 were infected, or 23 per cent. The longevities of the last adult in 2 lots were 60 and 106 days, respectively, on healthy celery.

Chlorotettix similis failed to transmit the curly-top virus. One lot of 30 adults was kept on a curly-top beet for 4 days and then transferred to a healthy beet for 2 days. The surviving adults were transferred alternately to curly top and healthy beets during adult life, but no disease resulted.

SUMMARY

With single-insect tests, the following percentages of transmission of California aster-yellows virus were obtained:

	To celery	To asters
Macrosteles divisus:		
Short-winged	69	69
Long-winged	9	62
Cloanthanus irroratus	1	1
Cloanthanus dubius	13	0
Euscelis maculipenis	77	0
Fieberiella florii	20	..
Chlorotettix similis	12	..

When from 5 to 40 insects per plant were used, percentages of transmission to celery were increased with all species tested (*Cloanthanus irroratus*, *Cloanthanus dubius*, long-winged *Macrosteles divisus*, *Fieberiella florii*, and *Chlorotettix similis*), and to aster with *Cloanthanus irroratus*. *Cloanthanus dubius* failed to transmit the virus to aster even with multiple lots. Other species were not tested in multiple lots on aster.

The virus was retained for a maximum of 15 days by *Cloanthanus irroratus*, 29 days by *C. dubius*, and 59 days by *Euscelis maculipenis*. Virus retention was not studied on other species.

Unsuccessful attempts were made to transmit the virus of Pierce's disease of grapevines to grape seedlings with two species (*Cloanthanus irroratus* and *Euscelis maculipenis*) and the virus of curly top to beets with three species (the two just listed and *C. dubius*).

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PLATE

Plate 1.—*A*, Male, *B*, female *Cloanthanus irroratus* (Van Duzee); *C*, male, *D*, female *Cloanthanus dubius* (Van Duzee); *E*, male, *F*, female *Euscelis maculipenis* DeLong and Davidson; *G*, male, *H*, female *Fieberiella florii* (Stål); *I*, female *Chlorotettix similis* DeLong.

CHARACTERS, DISTRIBUTION, AND FOOD PLANTS OF NEWLY DISCOVERED VECTORS OF CALIFORNIA ASTER-YELLOWS VIRUS

DWIGHT M. DeLONG and HENRY H. P. SEVERIN

CHARACTERS, DISTRIBUTION, AND FOOD PLANTS OF NEWLY DISCOVERED VECTORS OF CALIFORNIA ASTER-YELLOWS VIRUS[1]

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INTRODUCTION

FIVE LEAFHOPPER SPECIES are reported in the accompanying paper (Severin, 1947)[5] as vectors of California aster-yellows virus. The insects are illustrated by colored plates in that paper. The present paper deals with the characters, distribution, and food plants of these leafhopper vectors, which belong to the genera *Cloanthanus*, *Euscelis*, *Fieberiella* and *Chlorotettix*.

CLOANTHANUS ACUTUS (SAY)

Cloanthanus acutus has not been demonstrated to be a vector of the virus, but is included here because it has been confused with other species.

The species of *Cloanthanus*, formerly placed in *Platymetopius*, have been confused in their identity for many years because an attempt has been made to determine them by color pattern alone. These species unfortunately are too similar in color to distinguish several of the common species on this basis.

After a study of the Mexican and southwestern species, DeLong (1943) used the male genital structures to distinguish them. He showed that in many cases the structures are quite different. By means of those structures he set up a neotype (1945) for one of the common eastern species, *Cloanthanus acutus* (Say, 1831) illustrating the genital structures (fig. 1) and describing several closely related species in the East. From these studies it is obvious that several common or economic species have been erroneously identified in the past, and it is apparent that typical *C. acutus* does not occur in California nor the western United States in general.

CLOANTHANUS IRRORATUS (VAN DUZEE)

Cloanthanus irroratus (Van Duzee, 1910) is a brown species with a banded vertex and an irrorate face. In length it measures from 3.5 to 4.0 mm.

The vertex (fig. 2, *A*) is strongly produced and angled, and its median length is a little more than one third greater than the basal width between the eyes.

In color the vertex is dark brown with a wedge-shaped apical spot. A series of short pale longitudinal lines form a broken transverse band before the eyes. The base is also pale. The pronotum is brown with five pale longitudinal lines.

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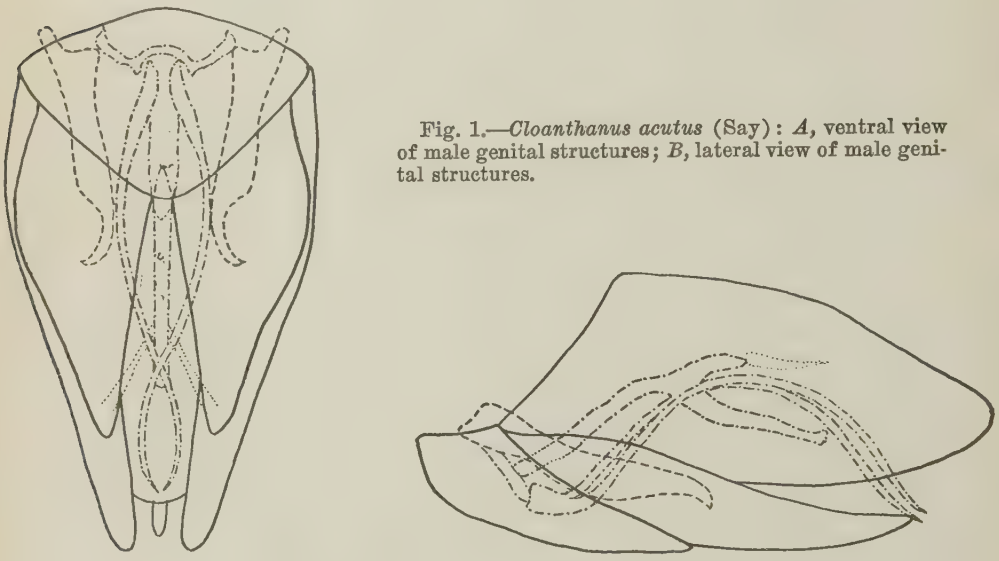
[4] The authors wish to express appreciation to R. V. Hershberger, Ohio State University, who assisted with the illustrations.
[5] See "Literature Cited" for citations, referred to in the text by author and date.

The scutellum is pale, the basal angles are orange. The elytra are rather sparsely irrorate forming several pale areas. The face is pale brown, irrorate with darker brown.

The female last ventral segment has the posterior margin produced in a broadly rounded shape.



A *B*

Fig. 1.—*Cloanthanus acutus* (Say): *A*, ventral view of male genital structures; *B*, lateral view of male genital structures.

The male genital plates are triangular (fig. 2, *B*). The style has a fingerlike apical process which curves outwardly (fig. 2, *C*). The aedeagus is broadly U-shaped with a basal stem. The apical portion of the stem has a pair of processes which are bent anteriorly.

The female segment is not different from that of most of the species of the genus. The male, however, is unique in the structure of the genital pieces, and the lateral view of the aedeagus will separate it at once from any of the other described North American species. A recently described Mexican species, *Cloanthanus apertus* DeLong (1943), is probably nearest in type of aedeagus. Of those species occurring in the United States *C. torridus* (Ball, 1916) is probably nearest in genital structure.

Geographic Range.—In his original description Van Duzee (1910) cited this species from Chino, Riverside, Pasadena, and San Diego, California; Phoenix, Arizona; and Tia Juana, Mexico. More recent records show its range extending to the states of Nuevo Leon and San Luis Potosi, Mexico (DeLong, 1943).

Distribution and Food Plants in California. During this study it has been collected in the following localities in California:

Riverside County: At Arlington on May 21, 1941, 2 females were obtained from an alfalfa field by N. W. Frazier.

Kern County: On December 21, 1941, at Arvin, a few adults were captured in miscellaneous sweepings by N. W. Frazier. The host plant is unknown.

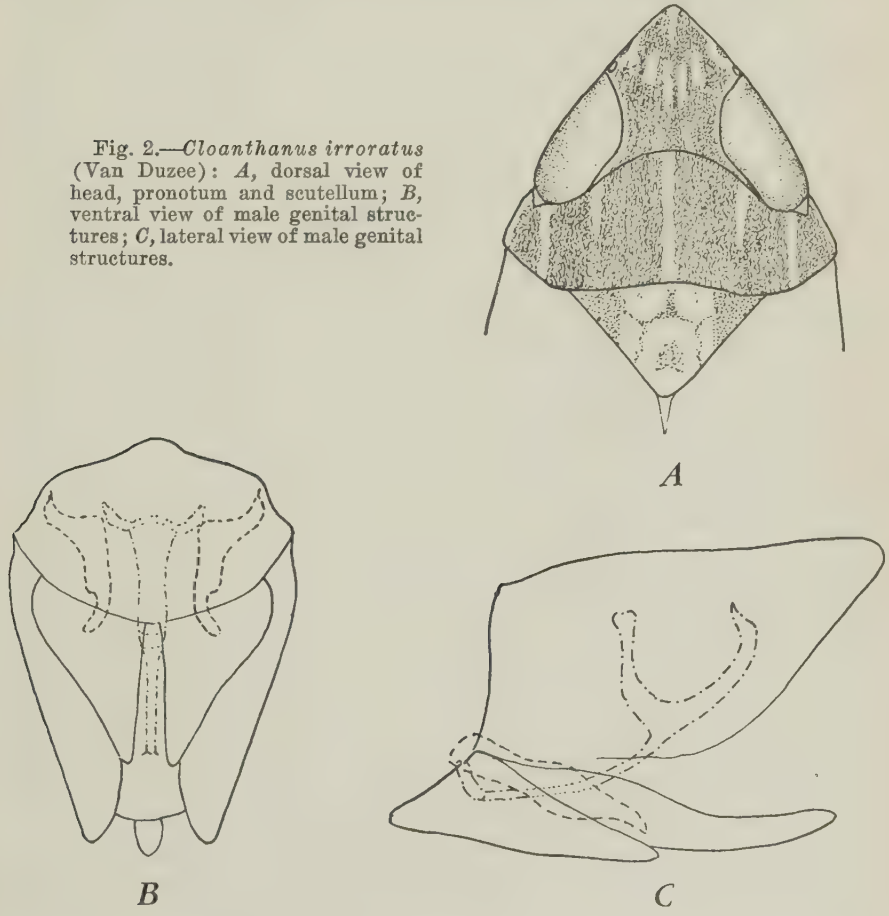


Fig. 2.—*Cloanthanus irroratus* (Van Duzee): *A*, dorsal view of head, pronotum and scutellum; *B*, ventral view of male genital structures; *C*, lateral view of male genital structures.

Madera County: At Madera on October 9, 1941, several adults were collected in an alfalfa field by H. H. P. Severin.

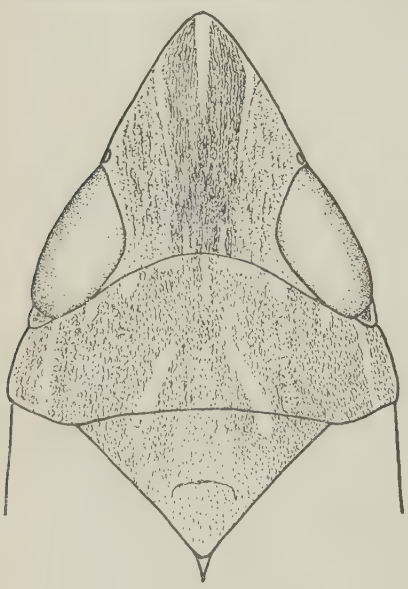
Sacramento County: In a locality known as Sacramento Pocket on September 12 and 18, 1941, adults were commonly taken on wild licorice, *Glycyrrhiza lepidota*, by H. H. P. Severin.

Sonoma County: Adults were caught in sweepings of mountain grape, *Vitis rupestris*, and California blackberry, *Rubus vitifolius*, at Triniti (in foothills near Cloverdale), May 8, 1940, by N. W. Frazier.

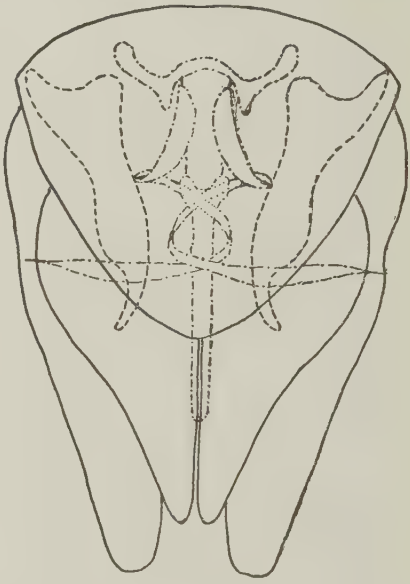
San Mateo County: On September 19, 1941, at Montara, a few adults were collected on weeds by H. H. P. Severin.

CLOANTHANUS DUBIUS (VAN DUZEE)

The leafhopper *Cloanthanus dubius* (Van Duzee) is given specific ranking in this discussion. Superficially it resembles *C. acutus* rather closely in form, color, size, and markings. Several years ago when it was named by Van Duzee



A



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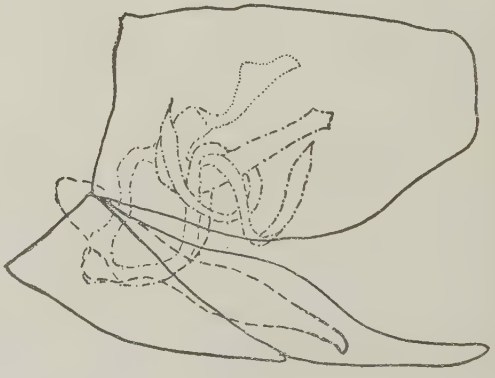

C

Fig. 3.—*Cloanthanus dubius* (Van Duzee): *A*, dorsal view of head, pronotum, and scutellum; *B*, ventral view of male genital structures; *C*, lateral view of male genital structures.

(1910, 1917), he placed it as a variety of *C. acutus* and did not take space to describe it. Since more detailed study has been made of speciation and characters to designate species, it seems advisable to give it specific ranking.

Cloanthanus dubius resembles *C. acutus* in form and color—dark brown with a pale face—but has distinct male genitalia (fig. 3, *B*, *C*). Its length is 5 mm.

The vertex is strongly produced and sharply angled (fig. 3, *A*). Its median length is about one and one half times as great as the basal width between the eyes.

In coloration the intensity varies from pale brown to dark brown. The male is usually darker in color than the female. The color is formed by rather closely spaced brown mottlings or rows of irrorate spots. The vertex in the male is dark brown with three slender white longitudinal stripes, one at the apex extending about one third the distance to base and one on either side about halfway from the apex to the eye, extending slightly obliquely toward base. In the female the vertex appears to have a broad dark median longitudinal band because the coloration is darker between the two lateral pale lines. The pronotum is brown with traces of five pale longitudinal lines. The scutellum has the basal angles usually darker, the central portion somewhat mottled with pale spots. The elytra have pale round areolar spots in the base or apex of cells on the corium, clavus, or in the apical or anteapical cells. The face is pale and darker just beneath margin.

The female last ventral segment has the posterior margin produced in a broadly rounded shape.

The male plates are rather short, rather broad at base, and triangular. The style is elongate, narrowed at about one third its length, and more deeply excavated on outer margin near apex to form a rather long slender fingerlike apex, which curves outward. The aedeagus is composed of a dorsal U-shaped portion and a pair of ventral processes which are long and vermiculate. The dorsal portion is rather broad, curved at base, the ventral piece of which is rather blunt at apex. The dorsal piece is much shorter and attached to a dorsal membranous portion. The ventral paired processes are long, normally curved about the ventral piece of the dorsal portion, broadened to form narrow bladelike structures on their apical fourth, and are sharply pointed at the apex.

As compared with the male genital structure of *Cloanthanus acutus*, the most striking differences are in the ventral piece of the dorsal portion and paired processes of the ventral portion. In *C. acutus* these paired processes are long and narrow, not broadened apically, and extend to the apex of the pygofer without being curved around the dorsal portion of the aedeagus.

Geographic Range. This species seems to be confined to the West Coast states and probably to California. It has been cited, apparently in error, from Quebec by Van Duzee (1908) and from Tennessee by DeLong (1916).

Distribution and Food Plants in California. Van Duzee (1914) reports this variety of leafhopper as not uncommon on the chaparral at Alpine and elsewhere in San Diego County.

N. W. Frazier collected this variety of leafhopper on pasture grasses and weeds in the following localities:

Sonoma County: Triniti, June 25, 1939; May 12, 1940; March 28, 1942; February 13, April 7, and June 4, 1943; and June 8, 1944.

Napa County: Dry Creek School, June 2, 1942; February 13, 1943.

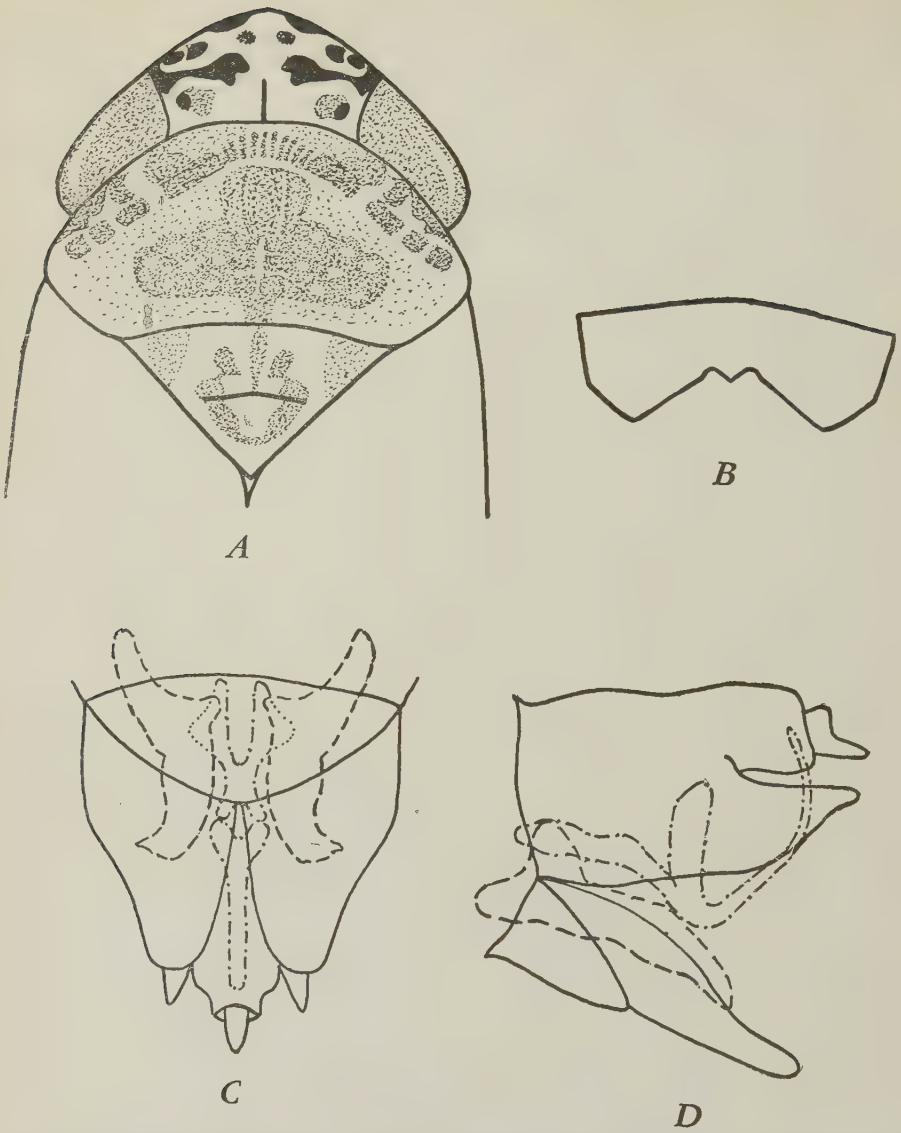

Fig. 4.—*Euscelis maculipenis* DeLong and Davidson: *A*, dorsal view of head, pronotum, and scutellum; *B*, ventral view of ninth female abdominal segment; *C*, ventral view of male genital structures; *D*, lateral view of male genital structures.

EUSCELIS MACULIPENIS DeLONG AND DAVIDSON

Euscelis maculipenis DeLong and Davidson (1934) is a rather robust species with a bluntly produced head which is marked with brown spots. It measures 5.0 to 5.5 mm in length.

The vertex (fig. 4, *A*) is bluntly produced, about one third longer in the

middle than next the eyes and is more than one third wider between the eyes than the median length.

The color is somewhat variable in intensity. Usually there is a row of four black spots just above the margin and a transverse spot on either side, sometimes divided, extending from the eye above the ocellus almost to the middle of the vertex. The pronotum is marked with black spots and transverse striae. The elytra are marked with small dark brown spots, especially paralleling or between the veins. These markings are more intensified in some specimens. The apices of the elytra are infuscated.

The last ventral segment of the female (fig. 4, *B*) has a posterior margin which is broadly excavated from the rather prominent lateral angles to a median broad, slightly produced tooth, which is black-margined.

The male valve (fig. 4, *C*) is bluntly triangular and the plates are rather broad, blunt, and rounded at the apices. The styles are rather elongate with broad blunt apices and a sharp-pointed spinelike projection on the outer apical margin. The aedeagus is rather slender and U-shaped. The basal third is thickened and bent dorsally, from the base of which the more slender portion slopes caudally and dorsally to the anal tube (fig. 4, *D*).

Geographical Range. This species was originally described from specimens from Idaho. It has since been collected in Oregon and California.

Distribution and Food Plants in California. The first population of this leafhopper was collected by J. H. Freitag in a depleted, grassy, alfalfa field near Milpitas on January 8, 1943. Nymphs were commonly taken in this alfalfa field in the spring, but during the summer the adults flew to other food plants. During 1943 to 1945 adults were captured by H. H. P. Severin in the spring, summer, and autumn in vegetable fields in South San Francisco on the following economic plants: celery, *Apium graveolens* var. *dulce;* common dandelion, *Taraxacum vulgare*; endive, *Cichorium endivia;* lettuce, *Lactuca sativa;* garden, table, or red beets, *Beta vulgaris;* Swiss chard, *B. vulgaris* var. *cicla;* and New Zealand spinach, *Tetragonia expansa.* Nymphs and adults were commonly collected on the following herbs: narrow-leaf sage, *Salvia officinalis;* rosemary, *Rosmarinus officinalis;* and sweet marjoram, *Majorana hortensis.* The adults were often taken on *Artemisia vulgaris* growing along the Russian River near Geyserville and the Napa River near St. Helena and Larkmead.

FIEBERIELLA FLORII (STÅL)

Fieberiella florii (Stål) (1864) was formerly called *Philipsius atropunctatus* DeLong (1923). It is a broad, flat-headed species, the upper surface of which is almost completely covered with small round black "pepper" spots. In length it measures 7.0 to 7.2 mm.

The vertex (fig. 5, *A*) is flat and one and one half times as wide between the eyes as the median length. The anterior edge is sharp. The elytra are rather broad, opaque, and flaring at the apices. The veins are rather obscure, and the appendix is wanting.

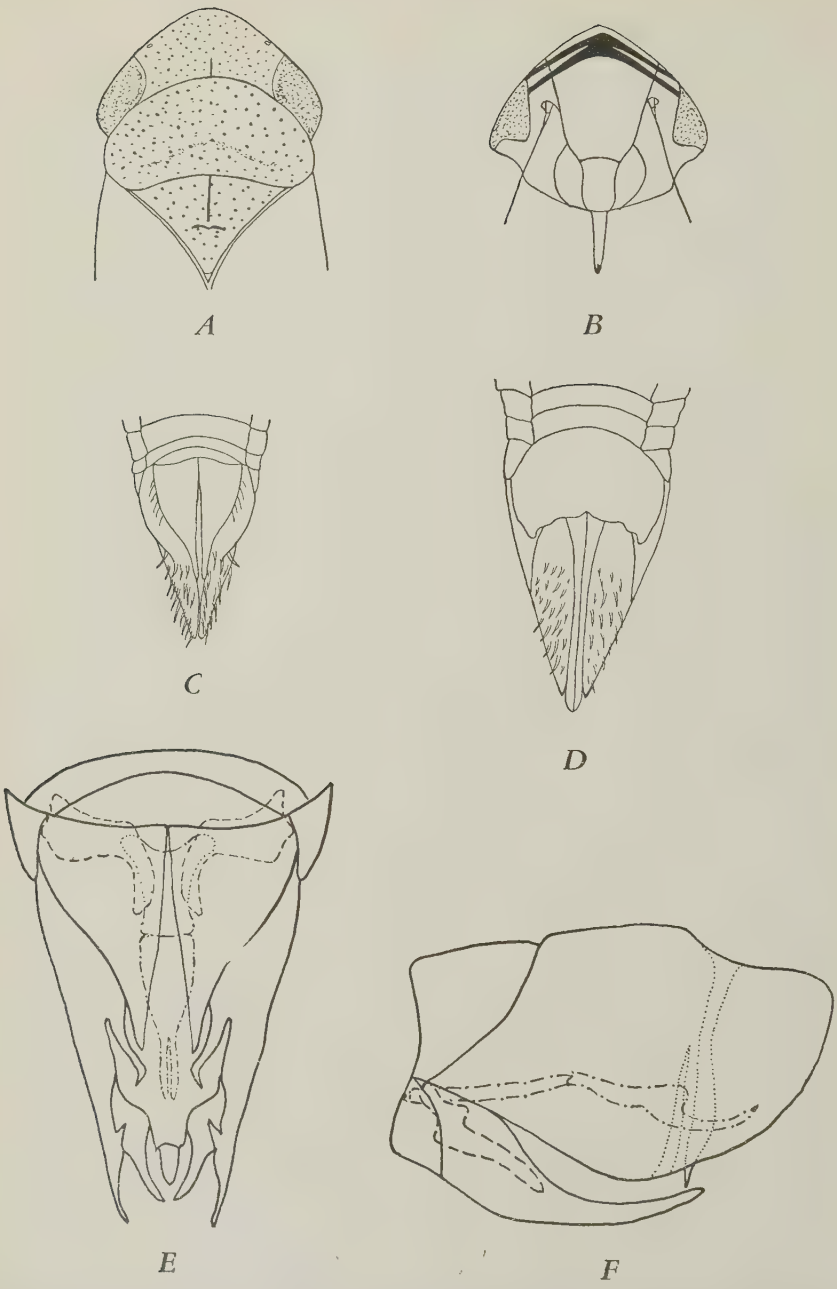

Fig. 5.—*Fieberiella florii* (Stål): *A*, dorsal view of head, pronotum, and scutellum; *B*, ventral view of head showing face; *C*, ventral view of posterior portion of male abdomen showing the valve, plates, and pygofer; *D*, ventral view of posterior portion of female abdomen showing ninth segment, pygofer, and ovipositor; *E*, ventral view of male genital structures; *F*, lateral view of male genital structures.

The vertex, pronotum, scutellum, and elytra are dull yellow, and rather densely and finely irrorate with round black spots. The veins are slightly brown and the apical veins are broadly margined with dark fuscous. The face (fig. 5, *B*) is yellowish with two heavy black bands, sometimes fused, just below the margin of the vertex. In the female the venter is white, the last ventral segment and pygofer brownish.

The female last ventral segment has rather prominent rounded lateral angles, between which the posterior margin is sinuately concave with a very shallow central notch (fig. 5, *D*).

The male plates (fig. 5, *C*) are elongate, triangular, longer than the combined width at the base and are narrowed to long acute attenuated apices. The styles are short, the apical third is rather narrow and curved outward. The aedeagus is thickened at the middle and narrowed on the apical third to form a pair of proximal fingerlike processes (fig. 5, *E*). There are two pairs of long spines on the pygofer. The longer pair are bladelike in appearance and extend from the dorsal margin to the ventral margin of the pygofer (fig. 5, *F*). The shorter pair extend dorsally from the ventral margin of the pygofer just beyond the middle of the aedeagus.

Geographical Range. This species was described from Europe and has apparently been imported into the United States upon ornamental plants. It was first found along the eastern coast and was redescribed by DeLong (1923) from Connecticut. It has since been found in Ohio, Illinois, and more recently in California. In the eastern states it is common on certain perennial ornamental plants.

Distribution and Food Plants in California. Napa County: The first population of this leafhopper was collected by J. H. Freitag on California privet (*Ligustrum ovalifolium*) growing as a hedge along the roadsides of the Beaulieu estate at Rutherford on August 9, 1944. Adults were captured by H. H. P. Severin on California privet growing on the Beaulieu estate on August 31, 1945, and on another hedge (*L. nanum* var. *compactum*) at St. Helena on the same date. On September 6 and October 4, 1945, and July 29 and August 9, 1946, adults were taken on classic myrtle (*Myrtus communis*) and on *Cotoneaster pannosa* growing on the grounds of the Napa Junior College. Nymphs were commonly collected on these host plants during April, May, and June but were rarely taken on these same host plants during the autumn. The leafhopper may overwinter in the egg stage in California, or the adults may fly to other food plants.

CHLOROTETTIX SIMILIS DeLONG

Chlorotettix similis DeLong (1919) is a pale-green, broad-headed species similar in appearance to *C. unicolor*, a common northeastern species. In length it measures from 6.5 to 7.5 mm.

The vertex (fig. 6, *A*) is broadly rounded and longer at the middle than next to the eyes. The width between the eyes is more than twice the median length.

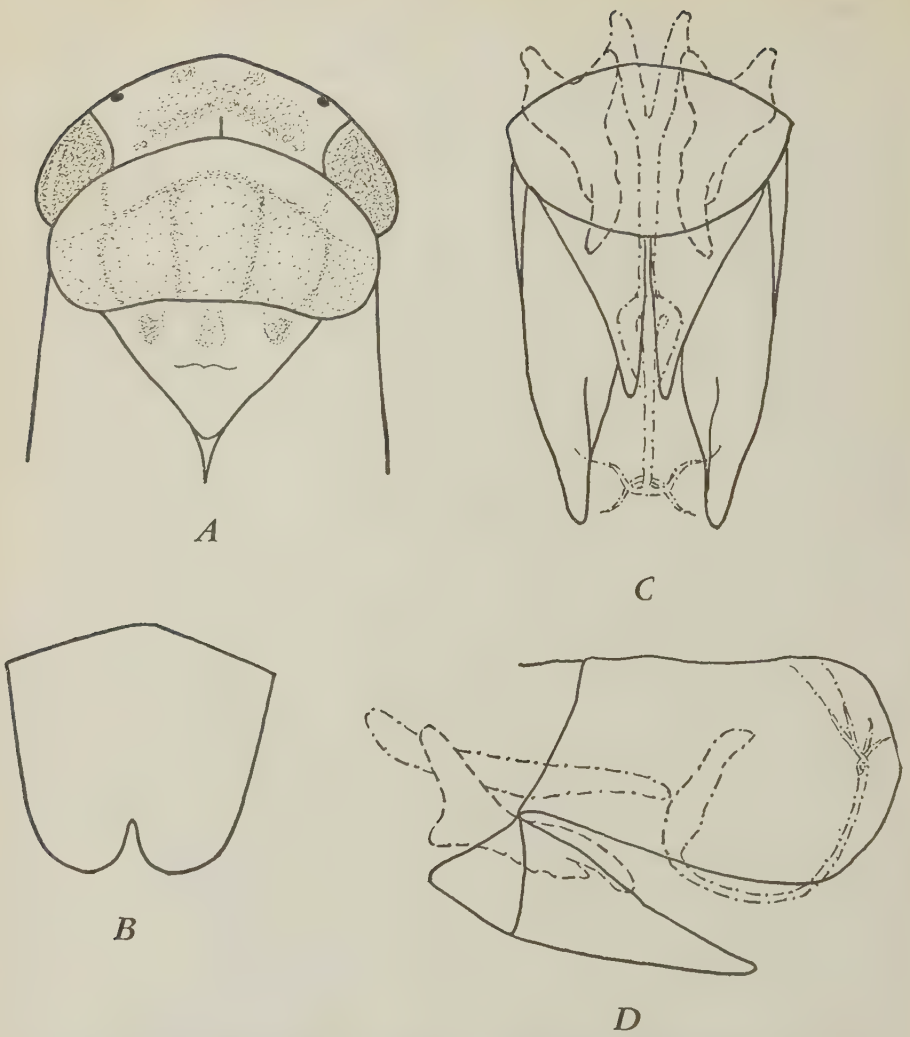

Fig. 6.—*Chlorotettix similis* DeLong: *A*, dorsal view of head, pronotum, and scutellum; *B*, ventral view of ninth segment of female; *C*, ventral view of male genital structures; *D*, lateral view of male genital structures.

In color the entire body is rather uniformly pale green without definite markings of any kind.

The female last ventral segment (fig. 6, *B*) is similar in type to that of *C. unicolor*, but is longer and more narrowed. The entire posterior margin is composed of two lobes, rather broadly rounded, which are formed by a V-shaped median notch, the sides of which are convexly rounded and after meeting, often overlap along the median line of incision. This incision extends one third of the way to the base. The whole surface of the segment is very rugose

and striated, the striae running transversely on the anterior half and longitudinally on the posterior portion.

The male plates (fig. 6, *C*) are triangular, the apices are narrow and pointed. The plates are much shorter than the pygofers. The styles are elongate, narrowed to bluntly pointed apices. The aedeagus (fig. 6, *D*) is long and slender with four slender terminal processes, two of which are short and two of which are quite long. The basal portion is bent dorsally and thickened and the apical half is bent dorsally.

Geographic Range. This is apparently the common broad-headed species of *Chlorotettix* in the Pacific Northwest and in California. It was originally described from Oregon and has since been recorded for California.

Distribution and Food Plants in California. Sonoma County: At Triniti, on June 4, 8, and August 14, 1943, adults were collected in miscellaneous sweepings.

Sonoma County: On June 7, 1944, at Geyserville a few adults were collected on *Artemisia vulgaris* by H. H. P. Severin.

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LONGEVITY OF NONINFECTIVE AND INFECTIVE LEAFHOPPERS ON A PLANT NONSUSCEPTIBLE TO A VIRUS

HENRY H. P. SEVERIN

LONGEVITY OF NONINFECTIVE AND INFECTIVE LEAFHOPPERS ON A PLANT NONSUSCEPTIBLE TO A VIRUS[1]

HENRY H. P. SEVERIN[2]

INTRODUCTION

In a recent paper (Severin, 1946),[3] evidence was presented that nine species of leafhopper vectors tested, completed the nymphal stages on celery or asters infected with the California aster-yellows virus, but died when transferred to healthy celery or asters. Conceivably, this might be either (1) because the virus itself is beneficial to the vector, or (2) because the host plant is modified by virus infection to become a more favorable food and breeding plant for the vector. This paper deals with the first possibility, through a comparative study of the longevity of noninfective and infective leafhoppers on a host plant nonsusceptible to the virus. If the virus is beneficial to the vectors, it is reasonable to assume that the adult life of infective leafhoppers reared during the nymphal stages on infected host plants would be longer on a host plant nonsusceptible to the virus, than that of noninfective adults kept on the same species of nonsusceptible host plant. On the other hand, if the virus is injurious to the vectors, then the longevity of infective leafhoppers would be shorter than that of noninfective adults kept on the same species of nonsusceptible host plant.

It is not the purpose of this paper to enter into a discussion as to whether the plant has been modified by virus infection to become a more favorable host plant for the vector.

METHODS

Short-winged and long-winged aster leafhoppers were used. The latter is a biological race of the same species, *Macrosteles divisus* Uhl. The noninfective insects were reared on mildew-resistant Sacramento barley, which is nonsusceptible to the virus. Infective leafhoppers were reared on diseased China asters (*Callistephus chinensis*) and plantain, or ribgrass (*Plantago major*).

In January, soon after the last molt, lots of 50 or 100 noninfective and infective male or female leafhoppers were confined in cages enclosing Sacramento barley. Each month the leafhoppers were transferred to thrifty growing barley plants, and a record was taken of the mortality.

RESULTS

Table 1 gives the results obtained. As shown in this table, no mortality of noninfective or infective adults of either vector occurred during the first month. An examination of the mortality records in the first test of the short-

[1] Received for publication November 4, 1946.

[2] Entomologist in the Experiment Station.

[3] See "Literature Cited" for citations, referred to in the text by author and date.

winged aster leafhoppers during the next four months shows a higher death rate of noninfective than of infective males, but the reverse is true when the data for the second test are compared.

TABLE 1

MONTHLY MORTALITY OF NONINFECTIVE AND INFECTIVE ADULT SHORT-WINGED AND LONG-WINGED *Macrosteles divisus* ON SACRAMENTO BARLEY, NONSUSCEPTIBLE TO ASTER-YELLOWS VIRUS

Sex and condition of aster leafhopper, and test no.	Adults in each lot	Cumulative mortality, per cent (Leafhoppers transferred to barley in January)					
		Feb.	Mar.	Apr.	May	June	July
Short-winged males:							
Test 1:							
Noninfective	100	0	20	34	88	97	100
Infective	100	0	19	40	92	98	100
Test 2:							
Noninfective	100	0	43	50	88	99	100
Infective	100	0	19	37	73	97	100
Long-winged males:							
Test 1:							
Noninfective	50	0	18	48	94	100	...
Infective	50	0	32	72	88	100	...
Test 2:							
Noninfective	50	0	28	54	86	98	100
Infective	50	0	30	62	88	98	100
Long-winged females:							
Noninfective	50	0	24	36	90	98	100
Infective	50	0	18	44	86	100	...

With both tests of long-winged aster leafhoppers, table 1 shows a higher mortality of infective than of noninfective adults, both male and female. The slight difference is not significant.

CONCLUSION

The results indicate that the virus itself is neither beneficial nor injurious to infective short-winged and long-winged adult aster leafhoppers, *Macrosteles divisus*, as determined by a comparison of the monthly death rate of noninfective and infective adults kept on a host plant nonsusceptible to the California aster-yellows virus.

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